Boll Weevil (Coleoptera: Curculionidae) Damage to Cotton Bolls Under Standard and Proactive Spraying

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ABSTRACT In some parts of the boll weevil's, *Anthonomus grandis grandis* (Boheman) (Coleoptera: Curculionidae), distribution from the United States to Argentina, insecticides are applied after cut-out (end of square production) when bolls are the predominant stage of fruiting body. This study demonstrates that the standard spray regime in southern Texas, which involves insecticide applications after cut-out, did not result in more bolls than a nonsprayed control. An alternative "proactive" spray regime focusing on protecting large squares before cut-out resulted in 1.9- to 2.5-fold more bolls in the lower half of the canopies than the control. At one of two experimental field locations, the percentage of damaged boll carpels was 3-fold greater in the standard spray regime's lower canopy than in the proactive spray regime, and the percentage in the control was 1.6-fold greater than in the standard regime. At both experimental field locations, the upper canopy control had 2.1- to 2.3-fold greater percentages of carpel damage than the proactive spray regime. The standard spray regime resulted in 2.3-fold greater percentage of carpel damage than the proactive regime. In the control and the standard spray regime, percentages of upper canopy nondamaged bolls were mostly lower than or not different from percentages of bolls with one, two, three, or all four carpels damaged, but in the proactive regime, percentage of nondamaged bolls in the upper canopy was greater than percentages of bolls with one or more damaged carpels. Reasons for the ineffectiveness of the standard spray regime and the benefits observed in the proactive approach are discussed.

KEY WORDS *Anthonomus grandis grandis*, bolls, boll, carpel damage, cotton, insecticide

The boll weevil, *Anthonomus grandis grandis* Boheman (Coleoptera: Curculionidae), is originally from the tropics and subtropics of Mesoamerica (Burke et al. 1986), but the modern-day distribution extends from temperate parts of the U.S. Cotton Belt to Brazil and Argentina (Ramalho and Jesus 1988, Rummel and Summy 1997, Cuadrado 2002). Boll weevil eradication efforts have occurred in temperate areas of the United States (Dickerson et al. 2001), and an eradication program commenced in the subtropical Lower Rio Grande Valley of Texas in late 2004 after an earlier program had begun and ended in 1995 without success. Increasingly rational boll weevil control tactics during the cotton growing season might assist eradication efforts in the subtropics and tropics where boll weevils are prevalent, active year-round (Guerra et al. 1982), and the efficiency of eradication might be weaker than in temperate climates where cold winters force boll weevils into diapause (Rummel and Summy 1997).

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As a source of food, large squares (5.5–8-mm-diameter) are preferred and contribute substantially more to boll weevil reproduction than smaller squares and bolls (Showler 2004b). Although squares fall from the plant 5–6 d after boll weevil oviposition in subtropical conditions (Showler and Cantú 2005), infested bolls do not necessarily drop (Stewart and Sterling 1989, Showler and Robinson 2005).

Preemptive insecticide applications for boll weevil control in cotton, as practiced in the Lower Rio Grande Valley, involves spraying when squares reach pinhead (1–2-mm-diameter) stage followed by one or two additional applications 3–5 d apart (Heilman et al. 1979, Showler 2004a). After this stage, insecticide applications are triggered at a threshold of 10% randomly selected oviposition-punctured squares, which occurs mostly after bolls become the predominant fruiting stage (Showler et al. 2005). Although some studies have indicated that preemptive spraying might delay the insecticide applications triggered by the 10% threshold (Heilman et al. 1979), other research shows that there is no beneficial effect (Showler 2004a, Showler and Robinson 2005), and economic advantages have not been demonstrated.

Sprays triggered by the threshold sometimes occur when large squares are predominant, but mostly they occur after the weevil population has started to increase and a substantial part of the overall weevil population is already protected inside the fruiting bodies (Showler and Scott 2005). Alternatively, a proactive spray schedule initiated when ≈2% of squares became large and at approximately weekly intervals thereafter for 4 wk until cut-out (Guinn 1986, Cothren 1999) resulted in 46–56% cotton lint yield increases mostly because large squares, the fruiting stage both most vulnerable to boll weevil infestation and contributing the most to the boll weevil's reproductive capacity, are protected (Showler and Robinson 2005). The extent to which bolls are damaged, however, is limited to reports that bolls, particularly young bolls, can be injured by boll weevils (Walker et al. 1977, Armstrong et al. 1980, Parker et al. 1980, Slosser et al. 1987), possible effects on boll abscission (Stewart and Sterling 1989), and that injury to a single carpel can occur without damage to the other carpels (Walker et al. 1977). Also, it is known that cotton plant genotypes can affect the vulnerability of bolls to boll weevil attack (Armstrong et al. 1980), possibly because in some genotypes, bolls mature and harden faster than in other genoptypes (Walker et al. 1977), making them less desirable or useful to the weevils (Cook 1906, Hunter and Pierce 1912, Fenton and Dunnam 1929). The impact of spraying insecticides against boll weevils when bolls are the predominant form of fruiting body has not been demonstrated. The purpose of this study was to assess the effect of two insecticide application approaches on protecting cotton lint in developing bolls from damage caused by boll weevils.

Materials and Methods

Field Experiment. A field experiment was conducted at the USDA–ARS Kika de la Garza Subtropical Agricultural Research Center (KSARC) and ≈2 km south at the KSARC annex called South Farm, Hidalgo County, TX, during 2004. The study was conducted at two locations during 1 yr because during the following year, 2005, the boll weevil eradication program (Dickerson et al. 2001) began, and this program involved mandatory applications of malathion on a schedule different from the standard or proactive approaches. At KSARC, a 1.8-ha experimental research field, planted to cotton (variety DP5415RR) on 2 March 2004, was divided into fifteen 0.12-ha plots, each 16 rows (1-m row spacing) in width by 160 m in length. At South Farm, a 1.9-ha experimental field, planted with the same variety on the same day, was divided into 15 plots of the same dimensions as at KSARC. Pendimethalin (Prowl, 3.3 EC, American Cyanamid, Parsippany, NJ) at 924 g (AI)/ha was applied by tractor immediately after planting, and weed control was thereafter conducted with a rolling cultivator or by hand-roguing. The fields were irrigated at the start of bloom in mid-May.

Five plots at KSARC and five plots at South Farm were given the standard boll weevil spray regime common to the Lower Rio Grande Valley, consisting of three preemptive insecticide sprays, 3–4 d apart, starting at pinhead square size (Showler 2004a). The plots were scouted every 2 d thereafter, and insecticide applications were triggered by finding 10% boll weevil infestation in 50 randomly sampled squares. Infestations in each plot reached 10 ± 1.2% (mean ± SE) in each plot at the same times. In our experiment, the standard spray regime consisted of cyfluthrin at 45 g (AI)/ha sprayed on 16, 20, and 23 April, 4, 20, and 25 May, and 2, 15, and 22 June at KSARC and South Farm. Cyfluthrin was applied through 16 Teejet 8003E nozzles, two angled toward each row, at a pressure of 3.5 kg/cm^2 (1.6 liters/min/nozzle) on a tractor boom. The 10% threshold was reached again on 27 June at both locations, but rain and muddy conditions curtailed further ground applications. Five plots at KSARC and five plots at South Farm were sprayed with cyfluthrin on 11 April, when ≈2% of the squares had become large, and at approximately weekly intervals on 18 April, 25 May, and 3 and 11 June (proactive spray regime). The remaining five plots at each location were not sprayed with insecticides (control). The three spray regimes were arranged in a randomized complete block design.

Numbers of plants in two 1-m section of row, and heights of 25 randomly selected plants, were recorded in each plot on 19 April (start of pinhead square development), 19 May (large squares predominant), and 7 July (predefoliation).

On 6 July bolls on a randomly selected 2-m-long sections of row in each plot (excluding the two outermost rows on each side of every plot) were removed, counted, and brought to the laboratory for dissection. Boll counts for the lower and upper halves of the plant canopy were recorded separately. Numbers of fallen bolls per two randomly selected 2-m-long sections of furrow were counted on the same date. Dissections involved cutting open each carpel on every boll lengthwise with a razor and the number of carpels infested by boll weevils were recorded. Damaged carpels were 75–100% eaten, blackened, or malformed. Percentages of total damaged carpels to total numbers of carpels, and numbers of damaged carpels per boll were calculated.

Cage Experiment. A 6.1- by 3- by 15.2-m (width by height by length) insect-proof field cage located 3 km south of KSARC in Hidalgo County was planted on 9 March 2005 with DPL-50 cotton on five 15-m-long rows on 1-m spacing. The plants were irrigated at planting and at first bloom. By 28 June, each plant had squares, and young (<10-d-old) and old (>2-wk-old) bolls. Small insect-proof cages were placed over each of 21 randomly selected plants. In seven of the cages, all fruiting bodies were excised from the enclosed plant. In another set of seven small cages, each enclosed plant was shorn of fruiting bodies excluding young bolls, and the remaining seven plants were left with only old bolls. Numbers of leaves and bolls per plant were recorded. On 29 June, 10 female boll weevils that had been mated and were ready to oviposit were released into each small cage and allowed to feed

Table 1. Mean ± SE cotton plant densities and heights at two locations during the start of pinhead square development on 21 April and on 19 May when large squares were predominant, 2004, Hidalgo County, TX

Location[a]	Treatment	21 April		19 May		7 July	
		Density/m row[b]	Ht (cm)[c]	Density/m row[b]	Ht (cm)[c]	Density/m row[b]	Ht (cm)[c]
KSARC	Control	36.2 ± 1.8	28.6 ± 1.4	29.8 ± 1.2	65.0 ± 2.7	27.2 ± 1.4	79.2 ± 4.8
	Standard	35.8 ± 2.0	30.4 ± 1.1	28.7 ± 2.1	64.0 ± 3.9	26.9 ± 1.8	81.4 ± 3.7
	Proactive	35.0 ± 1.8	31.0 ± 0.7	30.5 ± 1.5	69.0 ± 1.6	29.1 ± 2.3	81.8 ± 5.1
Ansul	Control	39.6 ± 0.4	27.8 ± 0.5	32.3 ± 1.3	66.0 ± 1.2	31.4 ± 1.4	80.3 ± 4.4
	Standard	37.6 ± 1.3	28.2 ± 0.4	33.3 ± 2.7	64.8 ± 1.0	32.2 ± 1.6	78.9 ± 4.7
	Proactive	38.8 ± 0.7	28.0 ± 0.9	30.8 ± 1.2	63.0 ± 1.6	31.1 ± 1.7	81.4 ± 3.1

[a] USDA-ARS experimental field sites ≈2 km apart.
[b] $n = 2$/plot.
[c] $n = 25$ plants/plot.

and oviposit for 5 d. Leaves were visually inspected for signs of perforation or petiole damage caused by boll weevil feeding. Weevils were then killed using an application of cyfluthrin on plants to runoff by using a hand-held Greenlawn (Gilmour, Somerset, PA) 2.8-liter capacity pump sprayer with the nozzle adjusted to a cone spray pattern at a pressure of 2.7 kg/cm^2. Applications were repeated every 5 d to avoid additional damage to bolls until data collection was complete.

Statistical Analyses. Differences between spray regimes in the field experiment were detected using one-way analysis of variance (ANOVA) (Analytical Software 1998). For field data that considered lower and upper portions of the canopy (subunits) as a factor, ANOVA was performed as a split-plot by using spray regimes and blocks as the other two factors (Analytical Software 1998). Means were separated with Tukey's honestly significant difference (HSD) (Analytical Software 1998). In the cage experiment, treatment effects were detected using one-way ANOVA and Tukey's HSD (Analytical Software 1998) for numbers of leaves, perforated leaves, and damaged petioles. Spray regime differences for numbers of bolls, damaged bolls, and carpel damage were detected using the two-sample *t*-test (Analytical Software 1998). Percentages of total damaged carpels in the upper or lower canopies were calculated based on total (damaged + nondamaged) carpels in the upper or lower canopies, respectively. Percentages of bolls with zero, one, two, three, or four damaged carpels were calculated based on total numbers of damaged carpels in the upper or lower canopies. Percentages were arcsine square root-transformed before ANOVA, but nontransformed data are presented.

Results

Field Experiment. Plant densities and heights did not differ between spray regimes during production of the season's first pinhead squares, whereas large squares were the predominant fruiting stage, and a week before defoliant was applied (Table 1).

A spray regime effect on numbers of lower canopy bolls per 2 m of row was detected at KSARC ($F = 5.30$; df = 2, 8; $P = 0.0342$) and South Farm ($F = 24.31$; df = 2; 8; $P < 0.001$). The mean number of bolls per 2 m of row in the proactive spray regime at KSARC was 2.5-fold greater than in the control ($P < 0.05$), and the standard spray regime was intermediate (Fig. 1A). At South Farm, lower canopy bolls were 1.7- and 1.9-fold more abundant in the standard and proactive spray regimes ($F = 19.47$; df = 2, 8; $P < 0.0001$), respectively, than in the control (Fig. 1B). Numbers of bolls within the upper canopies were not affected by the spray regimes. Also, differences in mean numbers of bolls per 2 m row also were detected between the upper and lower canopies at KSARC ($F = 53.39$; df = 1, 8; $P = 0.0001$) and South Farm ($F = 213.15$, df = 1, 8, $P < 0.0001$), excluding the KSARC control (Fig. 1A). At KSARC, lower canopy bolls were 3.2- and 5.3-fold more abundant than upper canopy bolls in the stan-

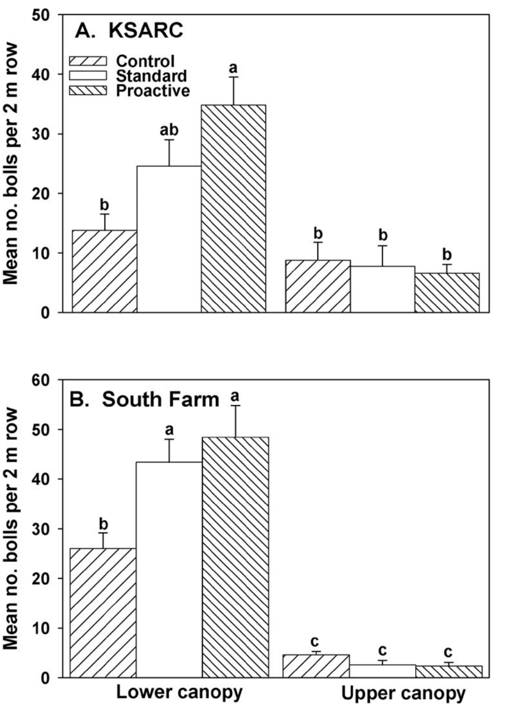

Fig. 1. Mean ± SE bolls on cotton plants per 2 m of row on 6 July 2004 at KSARC (A) and South Farm (B), Hidalgo County, TX. Different letters over the bars indicate significant differences ($P < 0.05$).

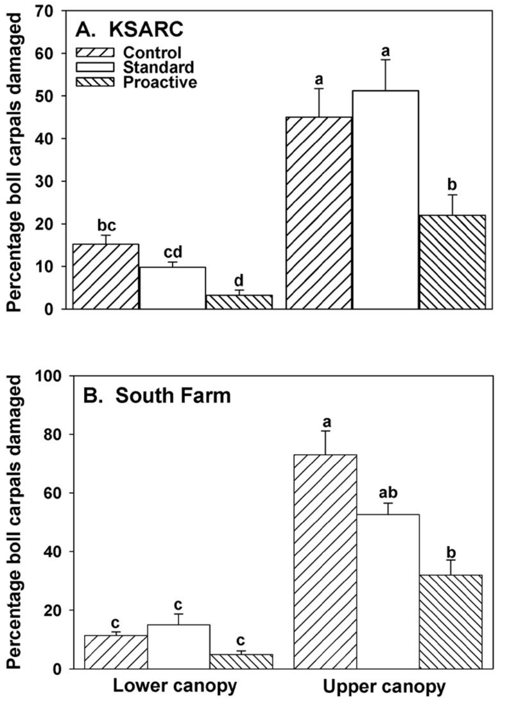

Fig. 2. Mean percentages ± SE of damaged carpels in bolls on 2 m of row on 6 July 2004 at KSARC (A) and South Farm (B), Hidalgo County, TX. Different letters over the bars indicate significant differences ($P < 0.05$).

dard and proactive spray regimes, respectively ($P <$ 0.05) (Fig. 1A); South Farm lower canopy bolls were 5.6-, 16.7-, and 20.2-fold more abundant ($P < 0.05$) than in upper canopies of the control, and the standard and proactive spray regimes, respectively (Fig. 1B).

Spray regime differences were found between mean percentages of damaged boll carpels at KSARC ($F = 14.71$; df = 5, 29; $P < 0.0001$) and South Farm ($F =$ 34.07, df = 5, 29, $P < 0.0001$), and differences between the upper and lower canopies were also detected (KSARC, $F = 150.10$, df = 1, 8, $P < 0.0001$; South Farm, $F = 135.01$, df = 1, 8, $P < 0.0001$). The percentage of damaged carpels in the lower canopy at KSARC was 4.8-fold greater ($P < 0.05$) in the control than in the proactive spray regime, and the standard spray regime was intermediate between them (Fig. 2A). At South Farm, no spray regime effects were observed in the lower canopy (Fig. 2, A and B).

At KSARC, percentages of damaged carpels in the upper canopy were 2.9-, 10.6-, and 8.1-fold greater than in the in lower canopy in the control, standard, and proactive treatments, respectively ($P < 0.05$) (Fig. 2A); at South Farm, percentages of damaged carpels per boll were 6.4-, 3.5-, and 9.4-fold greater, respectively ($P < 0.05$) (Fig. 2B). Percentages of carpel damage in KSARC upper canopies of the control and the standard spray regime were 2.1- to 2.3-fold greater than in the proactive spray regime. At South Farm, percentage carpel damage was 1.6-fold greater ($P < 0.05$) in the control than in the proactive spray regime, but the standard spray regime was intermediate (Fig. 2B).

Differences within each spray regime were detected between the percentages of bolls with either zero, one, two, three, or four damaged carpels in the upper or lower canopies at KSARC (control: $F = 6.47$; df = 4; 16, $P = 0.0027$; standard: $F = 31.65$; df = 4, 16; $P < 0.0001$; and proactive: $F = 20.34$; df = 4, 16; $P <$ 0.0001) and South Farm (control: $F = 21.03$; df = 4, 16; $P < 0.0001$; standard: $F = 8.51$; df = 4, 16; $P = 0.0007$; and proactive: $F = 32.31$; df = 4, 16; $P < 0.0001$). Percentages of nondamaged lower canopy bolls in the control, standard, and proactive treatments were, at a minimum, 6.7-fold higher than the percentages of bolls with one, two, three, or four damaged carpels at both KSARC and South Farm ($P < 0.05$) (Fig. 3, A and B).

In the upper canopies of the KSARC control, the percentages of bolls with zero, two, three, and four damaged carpels were not different, and at South Farm the percentages of upper canopy bolls with two, three, or four damaged carpels were greater than the percentage of nondamaged bolls ($P < 0.05$) (Fig. 3, A and B). In the upper canopies of the KSARC and South Farm standard spray regimes, percentages of nondamaged bolls and bolls with one, two, or four damaged carpels were not different from one another (Fig. 3, C and D). The percentages of nondamaged upper canopy bolls in the proactive treatment were greater than percentages of bolls with one, two, three, or four damaged carpels at both experimental locations ($P <$ 0.05) (Fig. 3, E and F).

Canopy position effect was significant only in the proactive regime at South Farm ($F = 12.97$; df = 1, 16; $P = 0.0024$), but interaction between spray regime and canopy position factors was detected at KSARC (control: $F = 3.47$; df = 4, 16; $P = 0.0319$; standard: $F = 17.87$; df = 4, 16; $P < 0.0001$; and proactive: $F = 4.56$; df = 4; 16, $P = 0.0120$) and South Farm (control: $F = 10.53$; df = 4, 16; $P = 0.0002$; standard: $F = 8.64$; df = 4, 16; $P = 0.0006$; and proactive: $F = 3.68$; df = 4, 16; $P =$ 0.02099). Canopy position effect was significant only in the proactive regime at South Farm ($F = 12.97$; df = 1, 16; $P = 0.0024$).

Cage Experiment. Numbers of leaves per plant were not affected by the spray regimes, but more leaves were perforated ($F = 31.72$; df = 2, 20; $P <$ 0.0001) and more leaf petioles were injured ($F = 90.35$; df = 2, 20; $P < 0.0001$) by adult boll weevils feeding on fruitless control plants than plants with either young or old bolls (Table 2). Numbers of young versus old bolls per plant were not different, but the percentage of bolls with visible exterior boll weevil oviposition punctures was 3.8-fold greater on young than old bolls ($t = 3.70$; df = 1, 14; $P = 0.0024$) (Table 3). Young bolls had seven times more weevil-damaged carpels than old bolls ($t = 4.98$; df = 1, 26; $P < 0.0001$) (Table 3).

Discussion

Based on the data, observed differences attributed to spray regime or canopy position factors are inde-

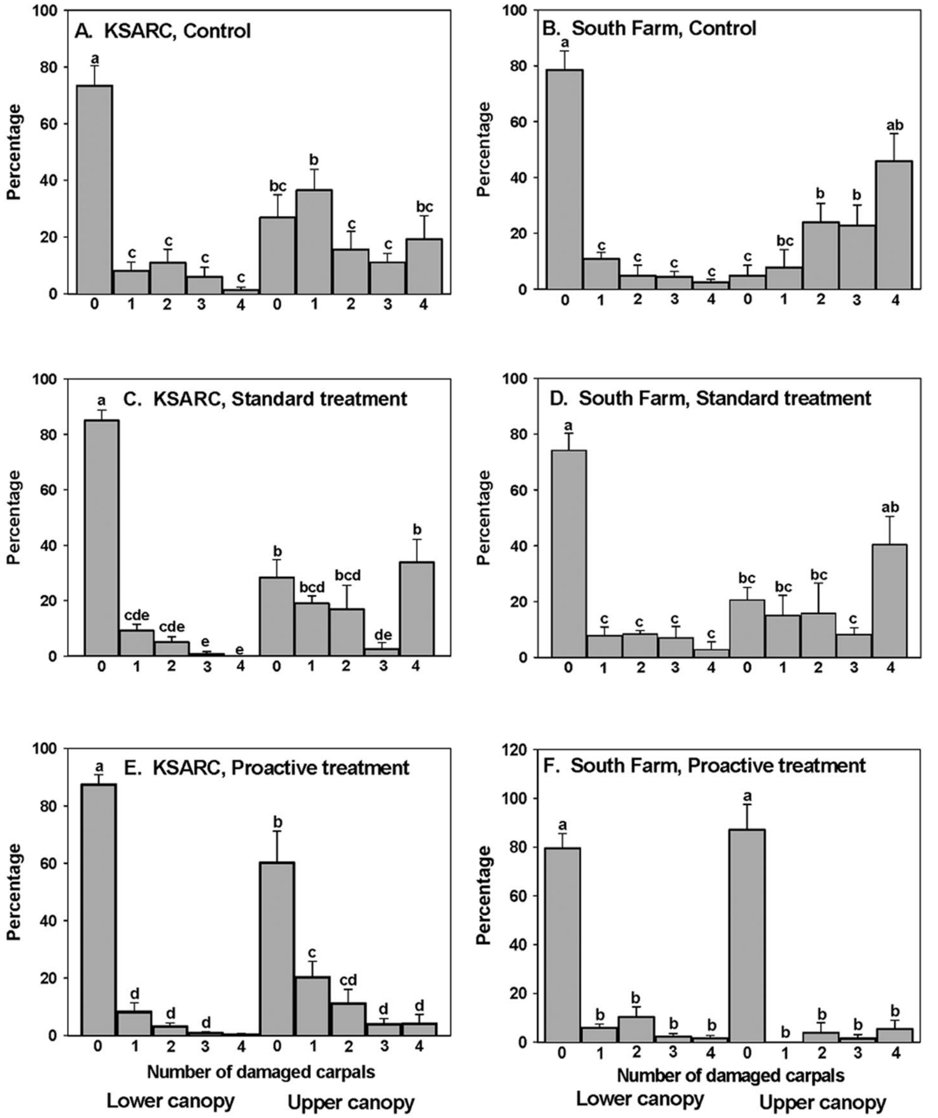

Fig. 3. Mean percentages ± SE of bolls that had zero, one, two, three, or all four carpels damaged on 2 m of row on 6 July 2004 in the control at KSARC (A) and South Farm (B); in the standard treatment at KSARC (C) and South Farm (D); and in the proactive treatment at KSARC (E) and South Farm (F), Hidalgo County, TX. Different letters over the bars indicate significant differences ($P < 0.05$).

pendent of plant density and height. Adult boll weevil populations were the same until the different spray regimes were applied (Showler and Robinson 2005).

Bolls were less abundant in the upper canopy than in the lower canopy. The difference is linked to acceleration of boll weevil population growth when large squares become available (Showler 2005), accompanied by the abscission of squares harboring weevil larvae (Coakley et al. 1969, Showler and Cantú 2005). Boll abscission, however, is negligible even after boll weevil populations have increased (Showler et al. 2005, Showler and Robinson 2005).

The lower canopies in all treatments had less boll weevil damage than the upper canopies. Because adult weevil population growth does not accelerate until after large squares become predominant, many bolls develop and harden while weevil numbers are still relatively low. The cage experiment demonstrated that although both young and old, hardened bolls are more attractive than leaves and petioles, old bolls are the least vulnerable to boll weevil injury (Cook 1906, Hunter and Pierce 1912, Fenton and Dunnam 1929). Planting early yielding varieties and optimizing planting dates have been suggested as ways of capitalizing

Table 2. Mean ± SE numbers of cotton leaves with perforations or petiole damage caused by adult boll weevils, Hidalgo County, TX, 2005

Treatment[a]	No. leaves/plant[b]	No. perforated leaves/plant[c]	No. injured leaf petioles/plant[d]
No bolls	34.6 ± 3.9	9.4 ± 1.7a	4.6 ± 0.5a
Young bolls	37.0 ± 4.0	0 b	0 b
Old bolls	36.3 ± 4.6	0 b	0 b

[a] No bolls, all fruiting bodies were removed from the plant; young bolls, only bolls <10 d old were left on the plants; old bolls, only bolls >2 wk old were left on the plants.
[b] $n = 7$ plants.
[c] Perforations were caused by adult boll weevil feeding, $n = 7$ plants. Values followed by different letters were significantly different ($P < 0.05$), one-way ANOVA, Tukey's HSD.
[d] Injured petioles were bent, causing the leaf to hang and die, $n = 7$ plants. Values followed by different letters were significantly different ($P < 0.05$), one-way ANOVA, Tukey's HSD.

on the cotton crop's loss of vulnerability to boll weevils as it matures (Heilman et al. 1979; Slosser 1993, 1995; Scott et al. 1998; Showler et al. 2005).

Unlike the more lightly-infested lower canopies, upper canopies in the control and standard spray regime lost the greatest percentages of carpels to boll weevils. Like the control, the standard spray regime had substantial percentages of completely damaged upper canopy bolls. In contrast, the proactive spray regime protected upper canopy bolls to the extent that percentages of bolls with one to four damaged carpels were considerably lower than percentages of nondamaged bolls.

Greater numbers of bolls in the proactive spray regime's lower canopies reduced percentages of damaged bolls in the upper (and in one location, lower) canopy positions; lower percentages of completely ruined bolls together contributed toward more harvestable lint than in the control and standard spray regime (Showler and Robinson 2005). However, because bolls were less abundant in the upper canopy than in the lower canopy, damage to those bolls had a smaller impact on yield.

Table 3. Mean ± SE numbers of young or old bolls damaged by boll weevil oviposition and larval development in the carpels, Hidalgo County, TX

Treatment[a]	No. bolls/plant[b]	% bolls damaged[c]	No. carpels damaged[d]
Young bolls	3.8 ± 0.6	48.9 ± 8.1a	1.4 ± 0.2a
Old bolls	4.0 ± 0.6	12.9 ± 5.4b	0.2 ± 0.1b

[a] Young bolls, only bolls <10 d old were left on the plants; old bolls, only bolls >2 wk old were left on the plants.
[b] $n = 8$ plants.
[c] Visible exterior damage caused by boll weevil oviposition, $n = 8$ plants. Values followed by different letters were significantly different ($P < 0.05$), one-way ANOVA, Tukey's HSD.
[d] $n = 14$ bolls. Values followed by different letters were significantly different ($P < 0.05$), one-way ANOVA, Tukey's HSD.

Insecticide applications after populations of large squares declined and bolls were predominant did not protect upper canopy bolls or lint. The standard spray regime also failed to adequately protect large squares (Showler and Robinson 2005), which was compounded by two other factors. The first factor is that insecticide applications do not kill boll weevils developing within fruiting bodies, and the toxic residue is effective for only 4 d (Showler and Scott 2005), but it takes 17.3–18.8 d for adults to develop from the egg stage (Hunter and Pierce 1912, Showler and Cantú 2005). The second factor is that the value of the 10% intervention threshold is compromised (Showler and Robinson 2005) by the decline in squares after cut-out (Guinn 1986, Cothren 1999).

The proactive spray regime more effectively protected lint production than the standard treatment because it was timed to disrupt approximately two generations of boll weevils that feed on reproduction-enhancing and vulnerable large squares when they are most abundant (Showler and Robinson 2005). After cut-out, boll weevils can still oviposit on young green bolls, which results in carpel damage, but older hardened bolls are less vulnerable (Walker et al. 1977, Parker et al. 1980).

As a source of food, bolls of any age are less preferred (Isley 1932) and do not contribute as much toward boll weevil fecundity as large squares (Showler 2004b); hence, population growth as well as protection of the highly vulnerable large squares was more tightly targeted by the proactive regime than by the standard approach. The data show that insecticide applications after cut-out did not protect bolls from weevil damage, but the proactive spray regime resulted in less damage to bolls.

Because the proactive spray regime had greater numbers of lower canopy bolls than the control, and numbers of upper canopy bolls were not affected by the spray regimes, lower canopy boll populations had a substantial influence on the lint yields, which were 46–56% greater than in the standard spray regime, and 46–120% greater than in the control (Showler and Robinson 2005). However, the different effects of the spray regimes on numbers of nondamaged carpels contributed toward the differences in lint yield. The proactive spray regime, with the highest percentages of nondamaged, fully productive bolls, was the most effective at protecting upper canopy carpels. The protection of large squares and boll carpels where boll weevils are not undergoing eradication (presently Mexico to Argentina) improves yield and economic return (Showler and Robinson 2005). We suggest, however, that proactive spraying also can augment, or become part of, boll weevil eradication strategies that involve diapause sprays, particularly if implemented on an areawide basis.

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